

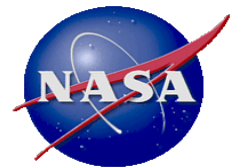
Autonomous Closed-loop Tasking, Acquisition, Processing, and Evaluation for Situational Awareness Feedback

Presented at GSAW 2016

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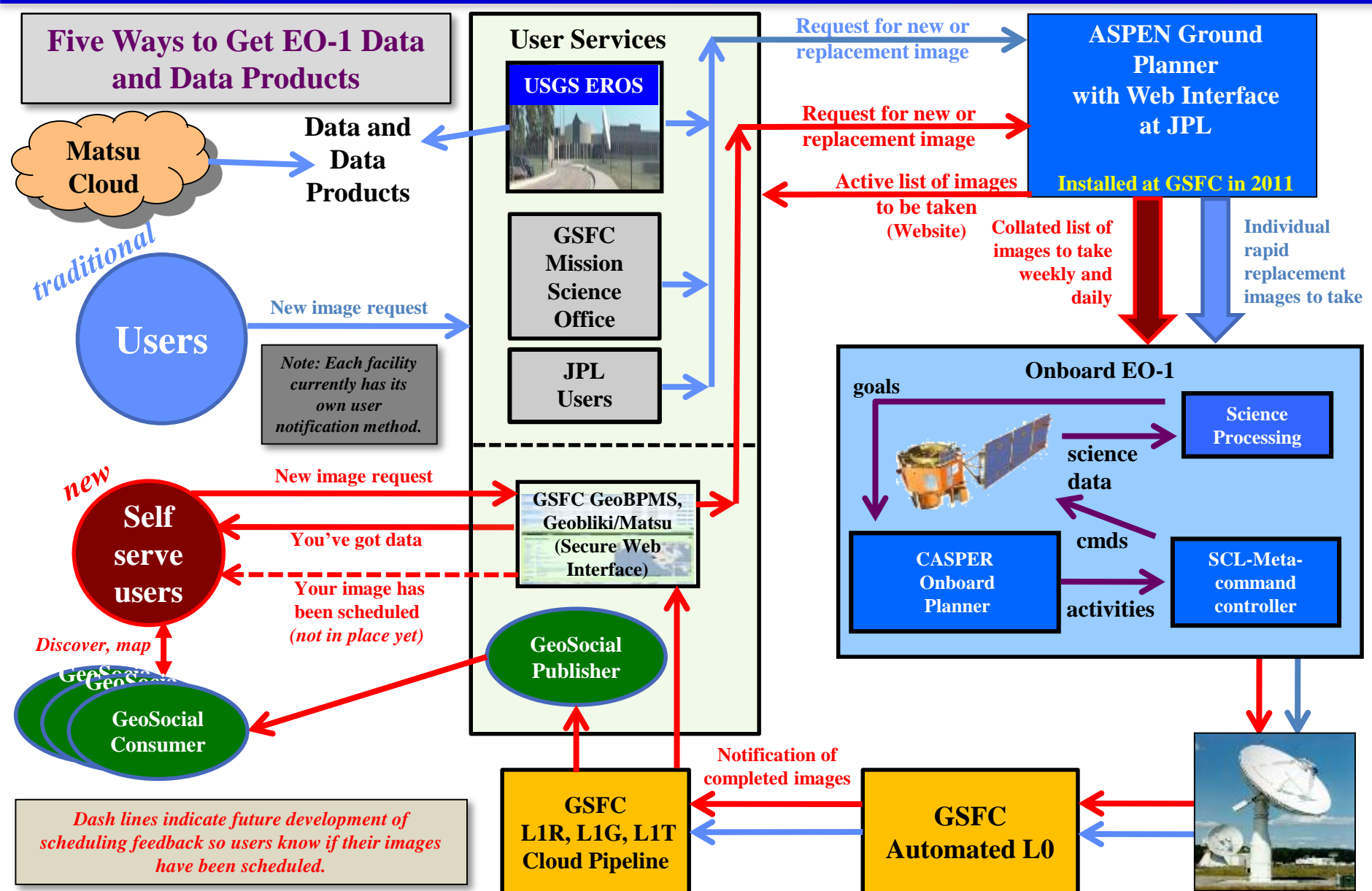
Co-authors: Dan Mandl (NASA), Pat Cappelaere (Vightel)

Overview of Features

- Closed loop satellite autonomy closes the gap between the users and the assets
- Base layer is distributed architecture based on GMSEC bus so each asset still under independent control
- Situational awareness provided by middleware layer through common application programmer interface to GMSEC components developed at GSFC
- User setup their own tasking requests, receive views into immediate past acquisitions in their area of interest, and into future feasibilities for acquisition across all assets
- Automated notifications via pub/sub feeds returned to users containing published links to image footprints, algorithm results, and full data sets
- Theme-based algorithms available for on-demand and processing

Example Ground System Architecture (NASA EO-1) for Autonomous Closed-loop Tasking, Acquisition, Processing, and Evaluation for Situational Awareness

Feedback



Distributed Architecture on GMSEC Bus

- Middleware services provide rest-ful API (not SOAP-WSDL interface)
- Nothing is centralized so no single point of failure
- Based on free-ware or open-source tools under the hood so minimal license fees
- Client workflows are orchestrated in javascript or Python using browser on user platform
- Servers run on Linux

Single Sign-On to All Middleware Services

- Security for access to services should be single sign-on handled by a distributed network of security servers that allow users to sign on once, then as they access other services in the network, those services verify with the security servers that the user is allowed to access and perform certain functions.
- This should apply not only to human interactions with the system, but with delegated authority to have machine-to-machine automated interactions on the users behalf.

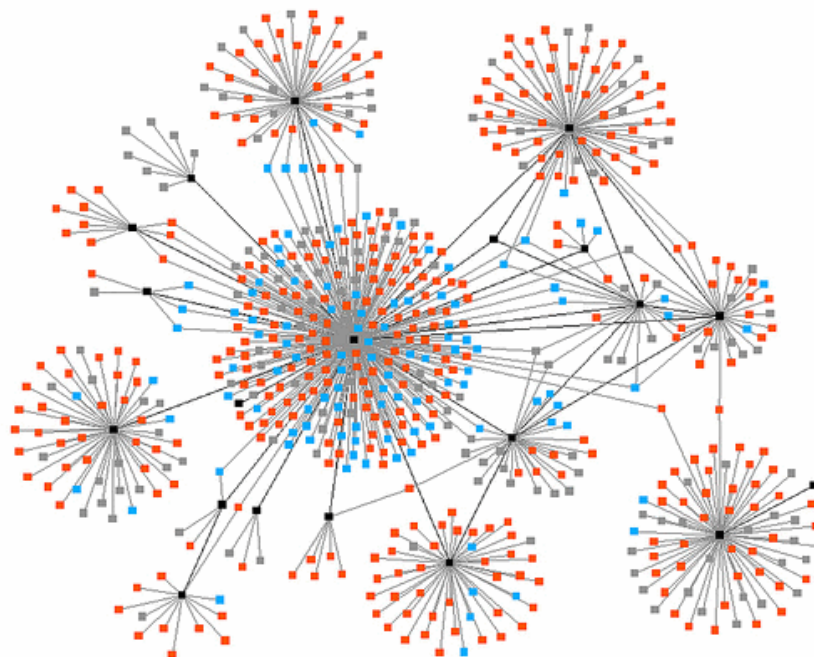
Welcome To the NASA GSFC SensorWeb OpenID Server (BETA 1)

Now supporting [Verisign Identity Protection \(VIP\) Services](#) for two-factor authentication

Please [get your own credentials](#) ASAP for a more secure access to the system

Building Securely The GEOSS Federation One Node At a Time...

Please [Login](#) or [New Account](#)



Target Identification and Submittal

- Users setup their own target requests using either coordinate entry, map box, or geonames (similar to an archive search tool)
- Users view their target requests as footprint locations on a map tool
- In-view dates and acquisition times for the target requests are automatically generated as feasibilities for all satellite assets going out at least 5 days
- Total column cloud predictions for each target in-view time and footprint location automatically supplied and updated every 3 hours going forward about 3 days
- Users are made aware of asset engineering activities that could block their request submittal from being executed
- Users view competing requests from other users to be able to judge likelihood of acquisition in support of task submittal decision making
- Near-term target requests are submitted to the scheduling system of each asset and the status of each request is maintained and visible to the users (status = submitted, scheduled, uplinked, acquired, downlinked, posted)
- Setup of a user target request automatically generates a subscription to receive notifications of data receipt for all images acquired in that target request area
- (See next page for example display)

Sample User Target Setup

[logout](#) | [help](#) | [main](#) | [users](#) | [scenarios](#) | [requests](#) | [tasking](#) | [schedule](#) | [pending](#) | [criteria](#)

Scenario/Campaign Entries

[Search](#) [Create New](#)

Name	Content	Theme	User	Scenario Requests	Created At	Updated At	Weight	Edit	Delete	Show
South America Science 2016	South America Science 2016	air	sfrye	King Sejong Station site , La Ciguena Santa Fe, Sinop-Mato Grosso, ...	01/26/2016 02:48 PM	01/26/2016 02:48 PM	0.0			
Kwando River Blockage	Kwando River Blockage Namibia/Angola border	flooding	sfrye	Kwando River Blockage	01/19/2016 01:52 PM	01/19/2016 01:52 PM	0.0			
Argentina Floods 20160105	Charter Activation for Argentina Floods 20160105	flooding	sfrye	Formosa Argentina 20160105 Charter, Asuncion Argentina 20160105 Charter	01/06/2016 07:07 PM	01/06/2016 07:07 PM	0.0			

Scenario/Campaign Tasking Requests for Argentina Floods 20160105

[Search](#) [Create New](#)

Id	Name	Content	Geolocation	Daynight Time	Center	Duration	Scenario Feasibilities	Scenario Requests Tasks	Edit	Delete	Show
5307	Asuncion Argentina 20160105 Charter	Asuncion Argentina 20160105 Charter	-25.3, -57.78	day time	Hyperion	12s	,,	-			
5306	Formosa Argentina 20160105 Charter	Formosa Argentina 20160105 Charter	-26.158, -58.265	day time	Hyperion	12s	,,	-			

2 Found

Mississippi River 20151229	Mississippi River 20151229	flooding	sfrye	Cape Girardeau MO 20151229, Vicksburg MS 20151229, St. Louis 20151229, ...	12/30/2015 01:09 AM	12/30/2015 02:15 PM	0.0			
Garland Texas 20151227	Garland Texas 20151227	flooding	sfrye	Garland Texas 20151227	12/28/2015 03:19 PM	12/28/2015 03:19 PM	0.0			
Holly Springs MS 20151223	Holly Springs MS 20151223	flooding	sfrye	Holly Springs/Ashland MS 20151223, Booneville MS 201512/23	12/24/2015 07:28 PM	12/24/2015 07:28 PM	0.0			
Shenzen China Landslide	Shenzen China Landslide 20151221	landslide	sfrye	Shenzen China Landslide20151221	12/21/2015 09:26 PM	12/21/2015 09:26 PM	0.0			
Phillippines Typhoon Melor	Phillippines Typhoon Melor 20151214	flooding	sfrye	Phillippines Typhoon Melor 20151214, Phillippines Typhoon Melor Naga, Phillippines Typhoon Melor Manila	12/14/2015 02:07 PM	12/14/2015 02:07 PM	0.0			
Nevado del Ruiz, Colombia	Volcan Nevado del Ruiz activity	volcano	eanderson	Nevado del Ruis activity	12/10/2015 08:13 PM	12/11/2015 06:04 PM	0.0			

Awareness for Timing of Delivery

- Users know in advance on a constantly updated basis exactly when to expect data from the next day's acquisitions from all satellites
- Image delivery availability and quality assessment used as input to the planning/scheduling for the following day's collections
 - For example, Landsat-8 data is acquired and assessed in time to affect decision about tasking for next EO-1 in-view target-by-target

[logout](#) | [help](#) | [main](#) | [users](#) | [scenarios](#) | [requests](#) | [tasking](#) | [schedule](#) | [pending](#) | [criteria](#)

Scenario/Campaign Tasking Opportunities

[Search](#) [Update Forecast](#)

Scenario Name	Theme	Id	Request	User	Org	Asset	Instrument Center	Date	Weather	Score	Tasks	Veto
Belm Germany	technology	79218	Osnabrück Germany	bsiegmann	IGF Osnabrueck	EO-1	hyperion	2016-02-03T08:35:00Z	21	0	EO11960242013112110KF(NOT FOUND), EO11960242013125110KF(rejected), EO11960242013159110KF(NOT FOUND)	-
West Africa - Rangeland	tropical	79599	Nazinga	Sumisu	UNKNOWN	EO-1	hyperion	2016-02-03T08:46:00Z	0	16		-
West Africa - Rangeland	tropical	79276	Aniabiisi	Sumisu	UNKNOWN	EO-1	hyperion	2016-02-03T08:47:00Z	0	16		-
South America Science 2016	air	79397	Santarem-Km67-Primary Forest	sfrye	SGT	EO-1	hyperion	2016-02-03T12:07:00Z	90	15		-
South America Science 2016	air	79370	Sinop-Mato Grosso	sfrye	SGT	EO-1	hyperion	2016-02-03T12:09:00Z	32	15		-
Argentina Floods 20160105	flooding	79083	Asuncion Argentina 20160105 Charter	sfrye	SGT	EO-1	hyperion	2016-02-03T12:13:00Z	98	15		-
Argentina Floods 20160105	flooding	79072	Formosa Argentina 20160105 Charter	sfrye	SGT	EO-1	hyperion	2016-02-03T12:13:00Z	100	15		-
South America Science 2016	air	79361	La Ciguena Santa Fe	sfrye	SGT	EO-1	hyperion	2016-02-03T12:14:00Z	13	15		-
Hong Kong, Shing Mun	tropical	79229	Fluorescence mapping	syedirteza	UNKNOWN	EO-1	hyperion	2016-02-04T01:07:00Z	42	0		-
South America Science 2016	air	79415	Panderos	sfrye	SGT	EO-1	hyperion	2016-02-04T11:08:00Z	70	15		-
South America Science 2016	air	79434	Eucaliptus Sao Paulo	sfrye	SGT	EO-1	hyperion	2016-02-04T11:10:00Z	99	15		-
South America Science 2016	air	79476	Atlantic Forest Sao Paulo	sfrye	SGT	EO-1	hyperion	2016-02-04T11:10:00Z	79	15		-

Rapid Assessment of Recent Images

- User is provided rapid assessment immediately after new images have been taken to visualize the image quality/cloud cover
 - Geolocated scene overlays of recently acquired data are published and notifications automatically fed to users in a compact file format that is appropriately named (asset ID, date, time, center-point coordinates, relevant geonames)
- Users are sent the image overlays and combine them with planned future footprints without having to search for them
 - Each asset posts image data in a centralized system, but users have particular information delivered to their consumer client on a distributed basis from regional product publishers
- The users can track which targets have been acquired vs. which ones aren't yet including not only the user's own target requests, but all images in the users' area of interest regardless of who submitted them
 - If an image was just taken of an area that fulfills the needs of some other user that was about to submit it for scheduling, then that user doesn't have to submit their request

Recent Acquisition Notification Process

Acquisition notifications are sorted with links to products

Upcoming collections are displayable on a map and on a timeline

EO1 Task Requests

Things you can do

[All Tasks](#) [All Tasks for past three months](#) [All Tasks for past year](#)

Stuart,

EO1 Task Requests are:

Taskid	Login	Acquisition Time	DOY	Scene ID	Lat	Long	Comments	Status
5137	sfrye	2016-02-04T01:07Z	035	EO11210452016035110KF	22.384306	114.142194	Fluorescence mapping Hong Kong country park Shing Mun	submitted
5138	sfrye	2016-02-03T12:09Z	034	EO12260682016034110KF	-11.4122916	-55.3247	Sinop-Mato Grosso Sinop-Mato Grosso	submitted
5136	sfrye	2016-02-02T14:41Z	033	EO10200462016033110KF	20.0929	-89.5639	Kaxil Kiulic Kaxil Kiulic	submitted
5135	sfrye	2016-02-02T11:34Z	033	EO12210712016033110KF	-15.95	-47.8666	Brasilia - Campo Sujo Quadrienal and Biental Tardia Brasilia - Campo Sujo Quadrienal and Biental Tardia	submitted
5134	sfrye	2016-02-01T14:08Z	032	EO10160522016032110KF	11.0166	-85.5	Los Inocentes Los Inocentes	finished
5132	sfrye	2016-01-31T12:04Z	031	EO12270802016031110KF	-29.264	-61.028	La Ciguena Santa Fe La Ciguena Santa Fe	finished
5133	sfrye	2016-01-31T08:36Z	031	EO11950522016031110KF	11.186017	-1.568458	Nazinga Model important forage characteristics	finished
5131	sfrye	2016-01-30T12:59Z	030	EO10020602016030110KF	0.212333	-66.76473	Sao Gabriel da Cachoeira Sao Gabriel da Cachoeira	finished
5130	sfrye	2016-01-30T11:24Z	030	EO12190702016030110KF	-14.848277	-43.9879	Panderos Panderos	finished
5129	sfrye	2016-01-28T08:27Z	028	EO11940522016028110KF	10.84603	-0.911855	Aniabiisi Model important forage characteristics	finished
5128	sfrye	2016-01-28T06:56Z	028	EO11750722016028110KF	-17.63	23.16	Kwando River Blockage Kwando River Blockage Namibia border	finished

[KML file available here](#)

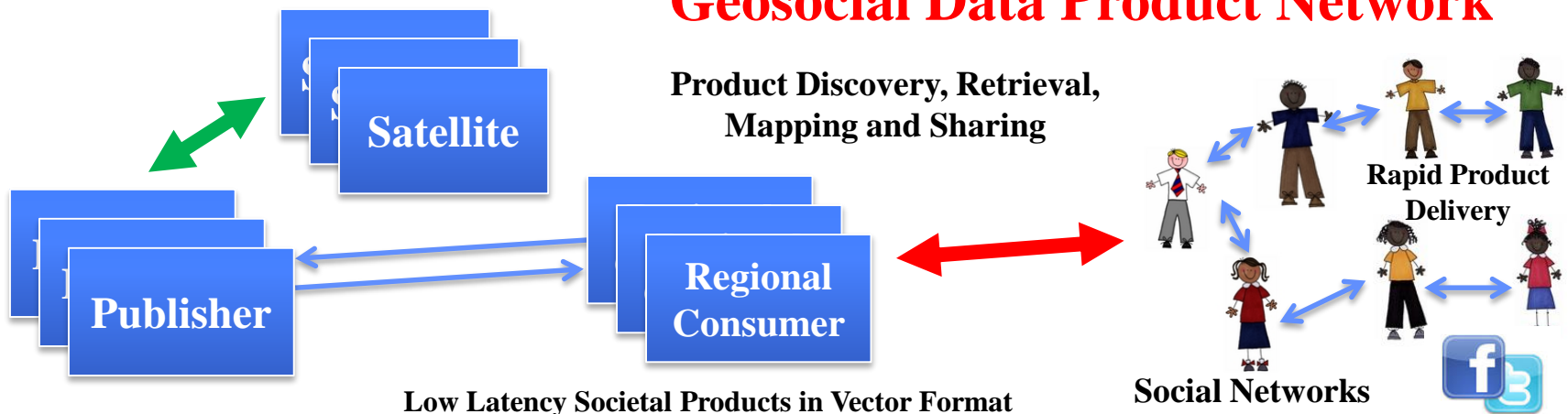


Autonomous Delivery of Recent Acquisitions to Regional Publishers for Browse Imagery and Classification/Detection Product Processing

Regional GeoSocial API Publisher/Consumer Network (HTML/HTTPS)

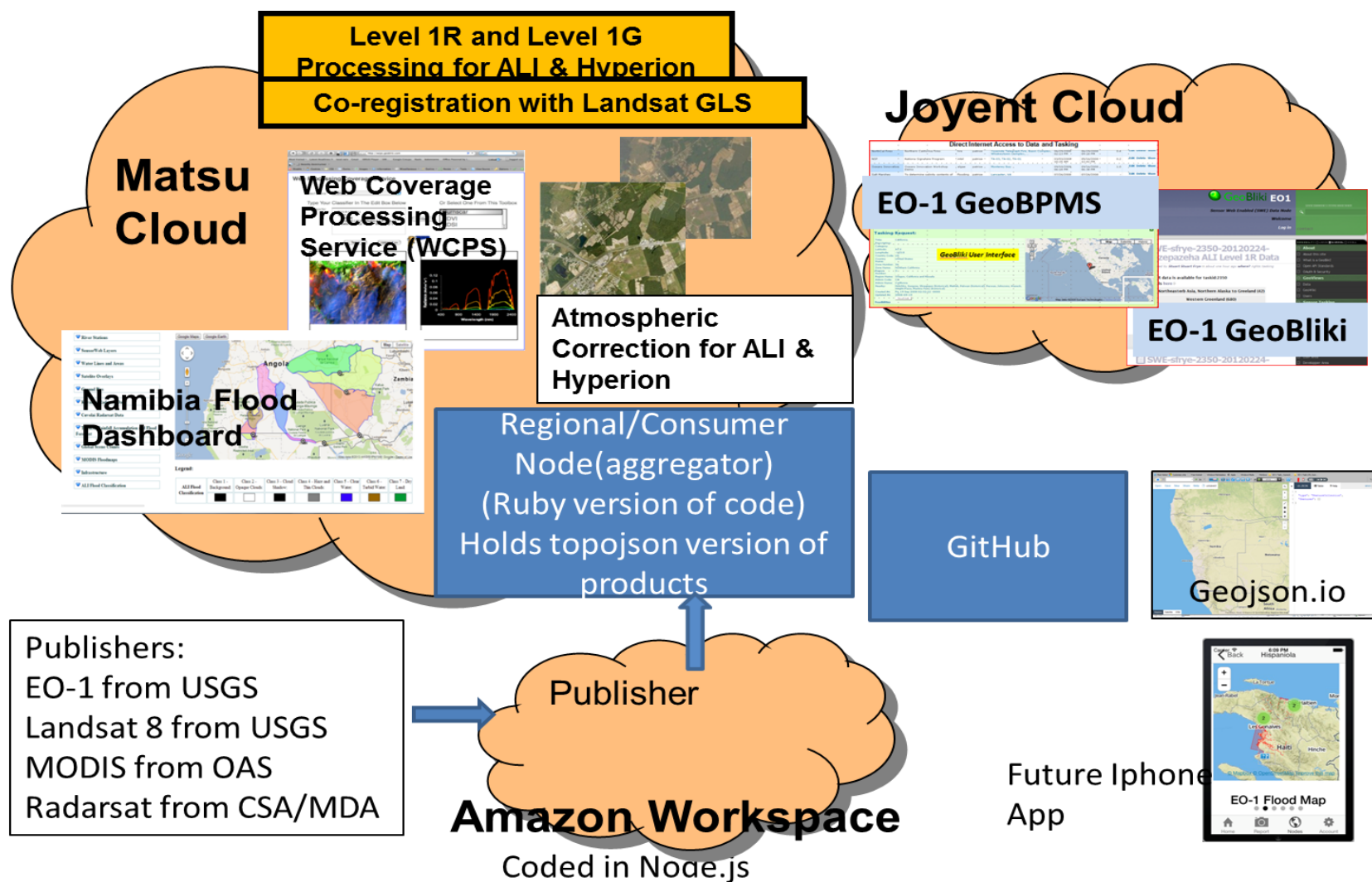
This is a *NEW* method to distribute EO-1 and other satellite data products in a compact vectorized format (small data size TopoJSON). The vision is to have a network of regional publishers automatically pre-generate specific satellite data products for a region and then make them available to all consumers in that region. The user obtains the data product by doing a Web browser query based on latitude-longitude. The publisher then provides the user a list of the available products in the region. The user clicks on the ones he/she wants to map and the vectorized data is downloaded to their computer, tablet, or smartphone for display. It is built in to share the products via Facebook/Twitter or other social media with a single click.

Geosocial Data Product Network



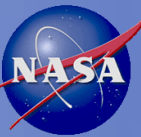
Cloud-based Processing and Delivery Overview

Distributed Cloud Architecture for EO-1 Data Product Distribution and Tasking Requests





Distribution Channel for Recently Acquired Products



GeoSocial API (architecture for discovery, retrieval, mapping, evaluation, and sharing)

The screenshot displays the GeoSocial Consumer interface. On the left, a sidebar contains a 'Geosocial Search - Prototype' section with search filters (Longitude, Latitude, Search, Start Time, End Time, Sources, Submit) and a list of products (Sample EF5 Product, EO1A1760722013027110KF, L1GST, EO1A1760722013027110KF, COREG, EO1A1760722013027110KF, L1T). Below this is an 'Infrastructure' section with '2014 Socioeconomic Data' and 'Matsu Wheel'. At the bottom, a 'GeoSocial Consumer Query: 6 results' section shows a 'Display' button and a list of products (id, type, name). The main area features a Google Map with a river and a boat track. A 'River Photo' window shows a photo of a boat. A 'GeoSocial Search - Prototype' window is also visible, showing search filters and a list of products. A 'Products choices appear here' window is at the bottom.

Dashboard > Home

matsu-namibiaflood.opensciencedatacloud.org

Geosocial Search - Prototype

Longitude, Latitude
21.7,-18
Search: Flood Map
Start Time: 2012-01-02
End Time: 2015-01-01
Sources: modis_list
Submit

Sample EF5 Product
EO1A1760722013027110KF
L1GST
EO1A1760722013027110KF
COREG
EO1A1760722013027110KF
L1T

Infrastructure

2014 Socioeconomic Data

Matsu Wheel

Geosocial Consumer Query: 6 results

Display

General Metadata Actions

id EO1A1760722013027110KF_SG1_01
type geoss.surface_water
name EO1A1760722013027110KF_SG1_01

Products choices appear here

GeoSocial Consumer with search for EO-1 and other satellite products by Lat-Long

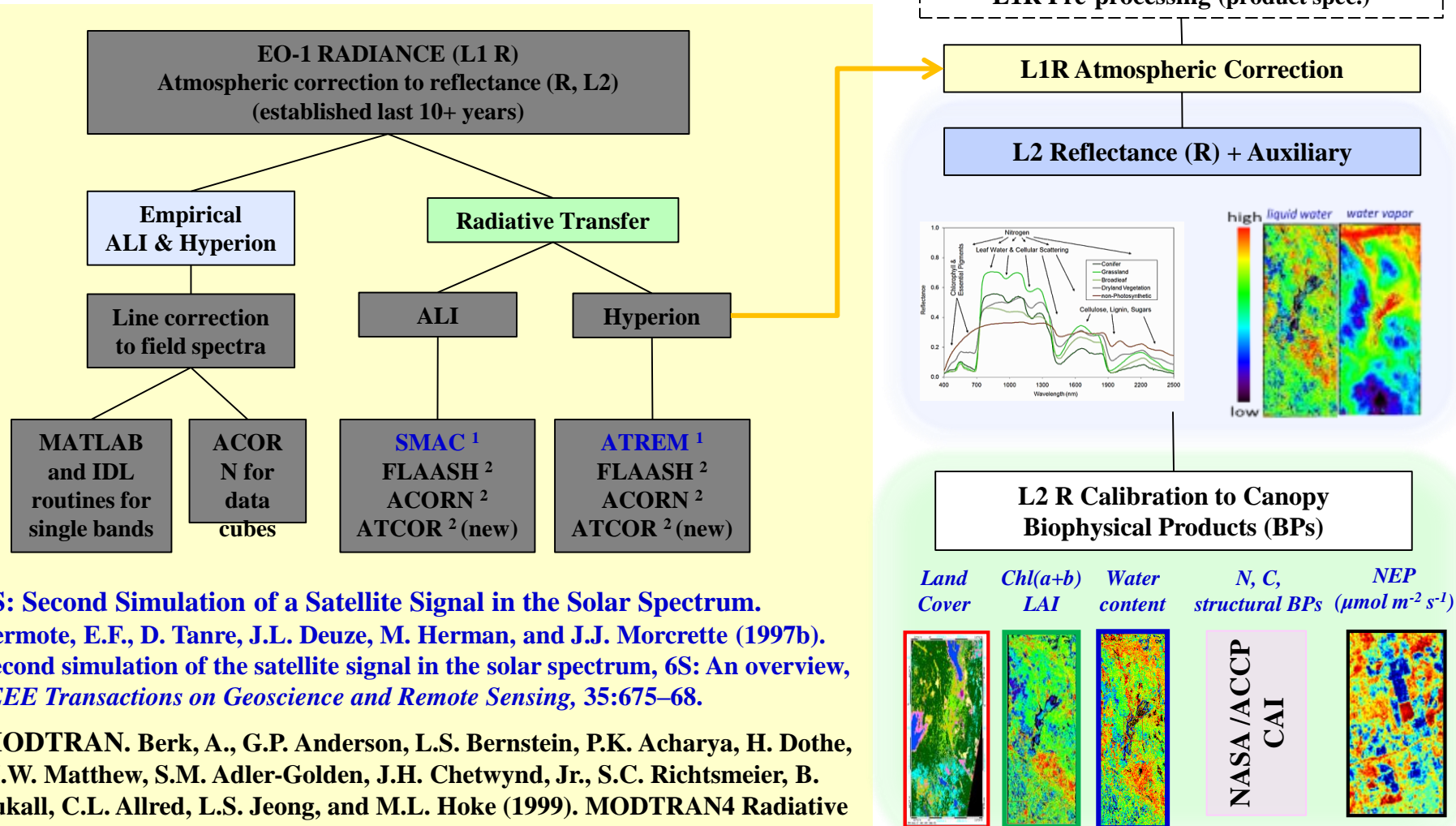
Crowdsourced GPS picture and boat track

EO-1 L1GST Water Extent Product Mis-registered

Select L1T co-registered product with Landsat GLS – fixes registration

User Controlled On-Demand Post Processing for Detailed Evaluation

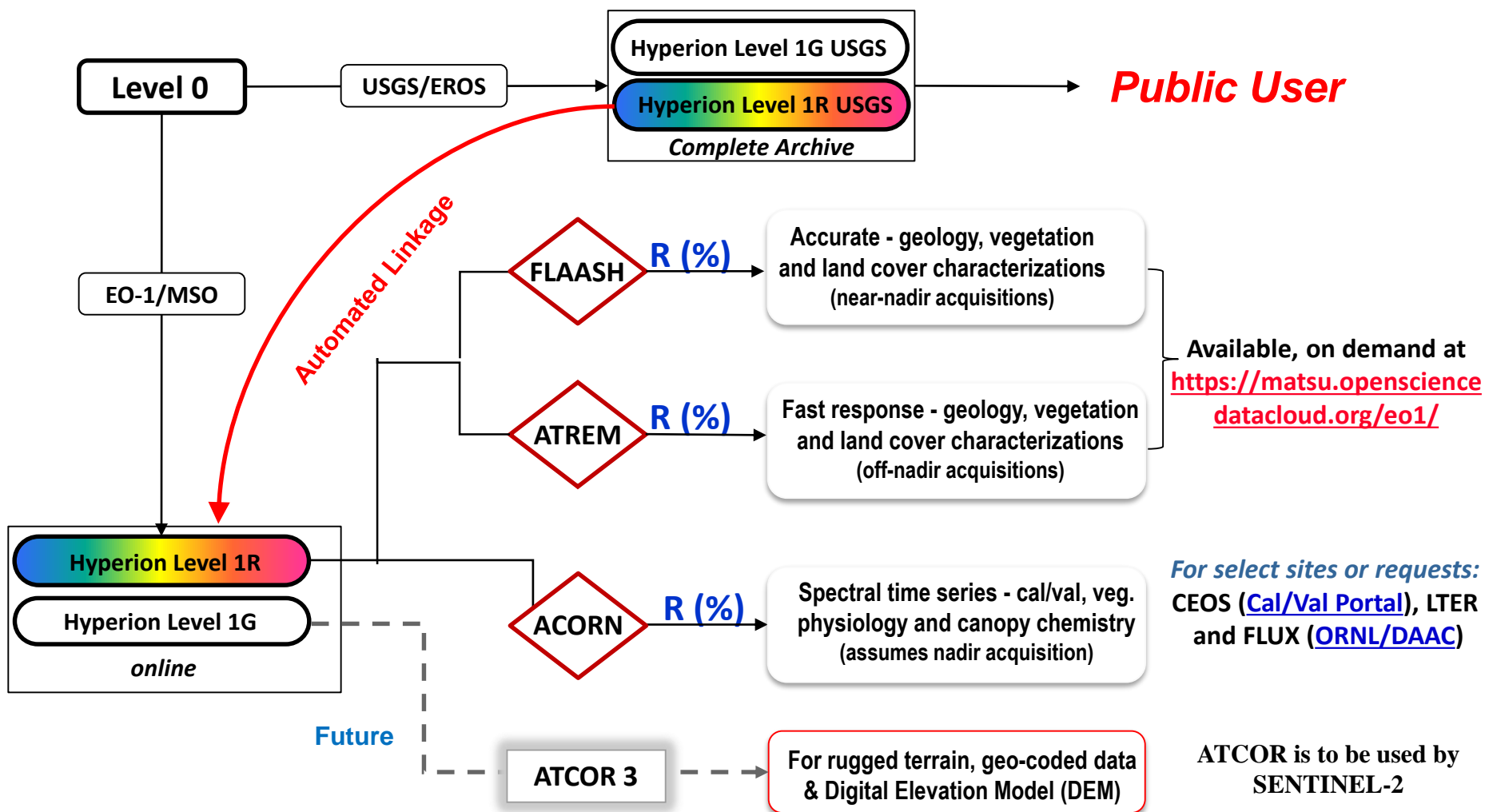
Reflectance Processing Protocols Established for ALI and Hyperion Level 2 Products



1. **6S: Second Simulation of a Satellite Signal in the Solar Spectrum.** Vermote, E.F., D. Tanre, J.L. Deuze, M. Herman, and J.J. Morcrette (1997b). Second simulation of the satellite signal in the solar spectrum, 6S: An overview, *IEEE Transactions on Geoscience and Remote Sensing*, 35:675–68.
2. **MODTRAN.** Berk, A., G.P. Anderson, L.S. Bernstein, P.K. Acharya, H. Dothe, M.W. Matthew, S.M. Adler-Golden, J.H. Chetwynd, Jr., S.C. Richtsmeier, B. Pukall, C.L. Allred, L.S. Jeong, and M.L. Hoke (1999). MODTRAN4 Radiative Transfer Modeling for Atmospheric Correction, *SPIE Proceeding, Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research III*, Volume 3756

Algorithms for Atmospheric Correction Processing Available for On-demand User-controlled Execution

Hyperspectral Level-2 Surface Reflectance Products



Coordination of Satellite Acquisitions with Flight Campaigns

Example: HypIRI Preparatory Airborne Campaign



Objectives:

- Acquire contemporaneous satellite images over flight boxes

Tactics:

- Satellite in-views by date and time for each box are visible to the flight team along with cloud predictions and other constraints during morning flight meeting
- Which flight area is to be flown today is identified in that meeting 4-5 hours prior to aerial lift-off based on cloudiness, satellite in-views, and engineering considerations
- Once flight box is identified, satellite target request for the selected box needs to be submitted, scheduled, uplinked, and executed within 4-5 hours to acquire data coincidentally with flight

Results:

- Maximum number of contemporaneous satellite and aerial images have been acquired

Thank You!

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